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ART. I.—*On "Carbolic Acid," its Composition, Properties, Uses in Surgery and as an Internal Remedy.* By J. H. BILL, M.D., Surgeon U. S. Army.

ATTENTION was first called to carbolic acid, as a remedy in medicine, by Lemaire, in 1860,[1] and more fully in 1863, in a work which reached a second edition in 1865.[2]

Lister, in 1866, apparently without knowledge of Lemaire's labours, commenced a course of untiring clinical experimentation, which he has continued to this day, founding what he calls the antiseptic system. His first results were announced in the *Lancet* in the spring of 1867.[3]

Recently, A. E. Sansom, M.D., Lond., has published a work on the "Antiseptic System," treating of carbolic acid as an antiseptic.[4]

Dr. Angus Smith has also published a work on "Disinfectants,"[5] to which we wish to acknowledge our indebtedness for many facts. The three authors first named unite in the effort to make carbolic acid chaperon the germ theory of disease. We think this endeavour is the cause of that opposition which Lister's practice has encountered from certain of his contemporaries, an opposition founded on prejudice, and almost passing into strife.

Until a very recent period, the chemistry of this body had been imperfectly known, even to chemists. This also has restricted its use in medicine. We know of a paper which appeared not long ago in a prominent chemical journal, in which the writer—a chemist—recommends carbolic acid as a styptic, asserting that, as all *acids* are styptics, carbolic acid must be a styptic—an extreme case to be sure, but showing that a body shrouded in mystery is liable to become the subject of marvellous tales. It has been in pretty general use for the past five or six years, although we think, in a rather hap-hazard way, with no design besides the benefiting a wound, and no belief in any property beyond a mysterious eutrophy. Can we doubt that it has been the scapegoat of much unmerited blame, possibly of undeserved praise?

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[1] Moniteur des Scs. Méd., 1860. Moniteur Scientifique, Oct. 1862.

[2] De l'Acide Phénique de son action, sur les vegetaux, les animaux, les ferments, les renius, etc. etc., par le Docteur Jules Lemaire, 2d edition, Paris, 1865.

[3] Lancet, March, 1867; July, 1867; February, 1868; June, 1869.

[4] The Antiseptic System; a Treatise on Carbolic Acid and its Compounds, by Arthur Ernest Sansom, M.D. Lond. London, 1871.

[5] Disinfectants and Disinfection, by Angus Smith, M.D. Edinburgh, 1869.

On the whole, the reports are in its favour, and it is gradually but surely gaining the favour of the profession, especially as a local application.

Before discussing the physiological or therapeutical bearing of the subject, let us pass in review the chemistry of carbol, as we beg leave to call it, and for which we hope presently to show a good reason.

Carbol was discovered in 1834, by Runge.[1] As it seemed to form salts with bases, he called it carbolic acid. Laurent[2] first obtained it pure, calling it phenylic hydrate. Gerhardt[3] subsequently proposed the name phenol, and Berthelot[4] extended this designation to the class of which carbol is a member. Carbol was long confounded with creasote (wood-tar oil), which is an uncertain mixture or solution of carbol, cressol, creasol, veratrol, etc., with several ethers, etc. The chemistry of carbol has been particularly elucidated by the labours of Cahours,[5] Hlasiwetz,[6] Hoffman,[7] Canizzaro,[8] Fittig and Tolens,[9] Calvert,[10] Kolbe and Lauterman,[11] and Kekulé [12]

Carbol crystallizes in needles of 1.066 sp. gr., melting at 34° C., boiling at 184° C., dissolving in twenty parts of water at 20° C., and in all proportions in alcohols, ethers, oils, etc. When heated and ignited, it burns with a yellow flame. In dilute solution, its taste is sweet, and excessively impressive. Whilst its odour in dry air is feeble and not fugitive, in moist air the odour is strong and evanescent. The crystals are soluble in twenty parts of water, remaining liquid at 20° C.

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[1] Poggendorf's Annalen, xxxi., xxxii.

[2] Annal. Chemie und Pharmac., xliii., xlviii.

[3] Annal. Chemie und Pharmac., xlv.

[4] Chemie Organique, i. p. 466.

[5] Annal. der Chemie und Pharmac., lxxiv., lxxvii., lxix., xli.

[6] Annal. der Chemie und Pharmac., cx., cxxxix.

[7] Annal. der Chemie und Pharmac., lxxvi., ciii.

[8] Annal. der Chemie und Pharmac., xc.

[9] Annal. der Chemie und Pharmac., cxxxi., cxxxiii.

[10] Quarterly Journal Chem. Society, xviii. 66.

[11] Jahresbericht, 1869–1870.

[12] Lehrbuch der Organischen Chemie, vol. ii. p. 521 to vol. iii. p. 250, the latest and best account of carbol and the aromatic series.

The formula of carbol is C_6H_5,OH.[1]

We know of no body with which carbol unites without change, a change so far as we know confined to a loss of its hydrogen or oxygen, and a replacement of these atom for atom by some other body. This exchange results in the formation of two classes of compounds, according as the hydrogen of the water residue OH, or as the hydrogen of the carbon nucleus C_6H_5, is substituted.

As a rule, the compounds formed by substitutions occurring in the water residue OH are unstable, carbol being easily reproduced from them, in some cases by physical means alone. When carbol and potassium react, we have an instance of the substitution of the hydrogen of the water residue by potassium. Thus $C_6H_5,OH+K$ becomes C_6H_5OK+H. This compound is very unstable, even carbonic acid will break it up. In the same way might have been substituted an alcohol radical; thus a body resembling an acid ether (*e. g.*, acetic ether) would have arisen. This hydrogen can also be replaced by the mineral acids, such as phosphoric—carbol—phosphoric acid arising. But all of these psuedo-salts, ethers, acids, etc., are unstable. The oxygen of the water residue is replaceable by sulphur, and phosphorus by double decomposition. It is removable without decomposition, as when carbol vapour is passed over red-hot zinc, benzine resulting; thus $Zn+C_6H_5,OH$ becomes $C_6H_5,H+ZnO$.

When the hydrogen of the carbon nucleus C_6H_5 is replaced by another body, the compound formed possesses tolerable stability. Thus by the action of chlorine on carbol or on its derivatives, all five atoms of hydrogen of the carbon nucleus C_6H_5 may be successively replaced by chlorine, mono, bi, tri, tetra, and quint chloro-carbols resulting. In the same way, the acid residue NO_2 can replace one, two, or three of these hydrogen atoms, forming mono, bi, and tri nitro-carbols (the last being picric acid). The acid residues SO_3H, and CO_2H (in the latter case salicylic acid being formed) may be similarly substituted. So also may the radicals of the alcohols, as methyl.

Carbol has a hydrate discovered by Calvert, and having the formula $C_6H_5O,H,\frac{1}{2}(H_2O)$. It may be prepared by adding four parts of carbol to one of water, and exposing it to a cold of 4° C. It crystallizes in six-sided prisms; we know of no other differences between it and carbol itself. When passed through a red-hot tube, carbol vapour is in part decomposed, a little naphthaline resulting. The statement of the text-books, and copied by Lemaire (*L'Acide Phénique*), that carbol heated with ammonia in a sealed tube is converted into aniline, has been recently shown by Berthelot to be incorrect.

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[1] Throughout this paper, the unitary notation is used, oxygen = 16, and is biatomic.

As yet, we have no means of estimating carbol. Its specific gravity, 1.066, is so nearly that of water, and its strongest aqueous solutions (5 per cent.) contain so little of it, that we cannot estimate it, as we do alcohol, by the specific gravity.

To detect carbol, Berthelot's is the best test. Thus, the liquid should be nearly colourless, free from aniline, or any body on which Labarraque's liquid will act. It should be warmed, made alkaline with a few drops of ammonia water, and then receive one-twentieth its bulk of the "Liq. Sodæ Chlor.," U. S. P. If the quantity of carbol present is very small after perhaps an hour, the liquid will be found faintly green, changing in twenty-four hours to a deep blue. The liquid becomes blue at once if a large amount of carbol is present. This blue passes into brown, and a brown-black precipitate falls. This test is characteristic. By it the one-hundredth of one per cent. of carbol can be recognized. The sense of taste, however, can also appreciate this dilution. When a ferric salt is added to carbol, a violet coloration occurs. The test is not characteristic; cressol, salicylol, saligenin, pyrocatechin, all allied to carbol, react similarly. The gases evolved by the action of chlorohydric acid on potassic chlorate convert carbol into tri-chlor-carbol, the odour of which is so strong and enduring that this reaction might serve as a test for carbol, if sure that chinon, salicin, etc., were absent. We are thus particular about the tests for carbol, because writers on this subject content themselves with declaring that they have readily detected carbol in the breath, urine, sweat, etc., without particularizing the method, and others fail to verify their results. We can confirm the statement of Lemaire (*L'Acide Phénique*, p. 118) that carbol does not interfere with the reaction by which oil of mustard is developed from myronic acid, nor by which bitter almond oil is developed from amygdaline by emulsin, provided 5 per cent. (or less) solutions be used. But carbol liquefied by a little heat and moisture retards the appearance of these oils for several days. We also found, as stated by Lemaire, that carbol does not interfere to prevent the conversion of starch into sugar by diastase. Lemaire believes that carbol does not act on pepsin, from the fact that dogs, to which he gave cheese, albumen, etc., mixed with carbol, digested it well. Our experiments made with infusion of rennet demonstrated that carbol did not interfere with the curdling of casein until 3 per cent. solutions were used.[1] Moreover, we have not observed, after exhibiting it remedially in doses of six grains, any interference with digestion.

Lemaire states that bodies affected with carbol readily part with it on exposure to air, and he uses this explanation to account for the fact that bodies like albumen, etc., after being carbolized, if exposed to the air, putrefy from loss of carbol (*De l'Acide Phénique*, p. 17, and note on p. 40). Our observations are not consistent with this explanation.

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[1] We know it is not proven that the curdling power of rennet is the same as the digesting power of pepsin. It is probable, however, that the curdling power is a property added to the ordinary digesting power of pepsin in young animals.

Most organic bodies retain traces of carbol sufficient to prevent putrefaction for a long time. In one case, some albumen coagulated by carbol and then exposed in an open vessel during a warm, but dry summer, at the end of four months still retained carbol, which it parted with only to warm water. Urea tenaciously holds carbol for a long while, so does gelatine and many other organic bodies. The fact is, the volatility of carbol depends greatly on the humidity of the air. Carbol possesses a great affinity for water, and the power of air to absorb it and carry it off depends, in a great degree, on the amount of moisture present. The neglect of this circumstance, and failure to correct the experiments, render the tabular statements of Sansom (at p. 14), "On the Volatility of Carbolic Acid," valueless.

The gases given off by the action of sulphuric hydride on barium peroxide, and on potassic permanganate, colour carbol solutions crimson. Sulphurous gas produces a yellow coloration. Gently heated with excess of ammoniac carbonate, a deep indigo-blue results. In short, the most striking chemical property of carbol is the variety and brilliancy of the colorations resulting in its reactions with other bodies.

For a long time, carbol was ranked among the acids. It seemed to form salts with bases. This opinion is still held both by Lemaire, *loc. cit.*, p. 41, and by Sansom, p. 65. Calvert,[1] however, whose results have been verified by Romei, has shown that when carbol is added to solution of potash, it dissolves, not in proportion to the amount of base present, which it should do had a salt been formed, *i. e.*, if carbol had played the role of an acid. We conclude, therefore, that carbol is not an acid.

Laurent,[2] at one time, regarded carbol as an aldehyde, assigning to its formula the construction $C_{12} H_6 O_2$ (old notation). But carbol is not an aldehyde, for it refuses to unite with acid sulphites and with aniline. All aldehydes unite with the former, and most unite with the latter.

The prevailing opinion, until very recently, has been that carbol is an alcohol—the hydrated oxide of phenyl; and some, whilst being driven from this opinion, still hold that it is a secondary alcohol like the isopropylic. Comparing it with wood spirit, we have $\left.\begin{matrix} C_6 H_5 \\ H \end{matrix}\right\} O$ $\left.\begin{matrix} CH_3 \\ H \end{matrix}\right\} O.$ Propyl. Alcohol (carbol), Methyl. Alcohol (Wood Sp.)

This formula-making of chemists is apt to mislead. It is merely guessing that a body whose elements are known and numbered has these elements arranged in a particular manner; and if this arrangement of elements is like that of any known class of bodies, we say (*i. e.*, we guess) the substance under consideration belongs to this class. In the case of carbol, we have guessed that it should be classed among the alcohols. It is an endeavour to represent probabilities which can become certainties only by the concurrence of known and, perhaps, at the time, unknown facts. When chemists say carbol is an alcohol, they really mean to say, Is carbol an alcohol? Its atoms may be arranged like the atoms of the alcohols, but are they so arranged? An answer to these questions can only be obtained from a study of the decompositions of carbol, and from a consideration of its relations to other bodies.

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[1] Quarterly Journ. Chem. Soc (2) vol. iii. p. 67.

[2] Révue Scientifique, vol. xiv. p. 341.

The only evidence for supposing carbol an alcohol is afforded by the fact that the hydrogen of the water residue can be replaced by a metal, or a radical, as we have seen. On the other hand, we find—

(1.) An oxidizing agent fails to convert carbol into a body like aldehyde, whence, by further oxidation and dehydration, an acid arises.

When an alcohol is so oxidized, first an aldehyde, and then an acid, is produced.

(2.) When chlorine acts on carbol, carbol chlorinated compounds arise.

When chlorine acts on alcohol, aldehyde is produced.

(3.) Nitric acid forms nitro-carbols (*e. g.*, picric acid), NO_2 being substituted for H of the *carbon nucleus* C_6H_5.

Nitric acid, with alcohol, forms ethers, NO_2 being substituted for H of the *water residue* OH.

(4.) Sulphuric acid forms, with carbol, carbol sulphuric acid, not convertible into ether.

With alcohol, it forms sulpho-vinic acid, convertible into ether.

(5.) The oxygen of the water residue OH of carbol, as of alcohols, is replaceable by phosphorus-chloride, bromide, etc., but with different results as respects the products arising. In the case of an alcohol, true chlorides, bromides, etc., of the alcohol radical arise, from which the alcohol can be readily reproduced, and which show double decomposition with water, alkalies, and acids. Carbol, on the other hand, when treated with phosphorus-chloride, yields chloro-benzine, from which carbol cannot be reproduced, which does not suffer double decomposition with water, alkalies, and acids, and which is not, therefore, a true organic chloride, like the chloride of the alcohol series.

A crowning objection to the hypothesis is this: The members of the carbol sereis (save carbol itself) have their atoms arranged in two different ways. When arranged in one way, they have the properties of carbol. In the other way, they have the properties of an alcohol. Thus the group of atoms C_7H_8O has been found to have two different arrangements. When arranged in one way, we have a true homologue of carbol—cressol—a body very like carbol in all its properties. Arranged in another way, we have benzilic alcohol—a true alcohol. A more correct statement is that the group of atoms C_7H_8O sometimes plays the role of a body like carbol, sometimes that of an alcohol; and in the latter case, we infer that its atoms must be differently arranged from what they are in the former. Or more fully stated, benzilic alcohol owes its properties to the fact that its atoms are arranged on the general plan of the alcohols. Cressol having the same composition as benzilic alcohol, has quite different properties. We infer, therefore, that its atoms must be arranged differently from the arrangement of the atoms of benzilic alcohol, and not on the plan of the alcohols in general, and hence cressol is not an alcohol. If cressol, and phlorol, etc., homologues of carbol, are not alcohols, carbol itself cannot be an alcohol. It has been replied to this that cressol (and carbol) is a secondary alcohol; *i. e.*, an alcohol containing the same atoms as the primary alcohol, but having them differently arranged—such an arrangement, in short, that on being oxidized it yields acetone, instead of aldehyde. Now, in the first place, cressol on being oxidized yields no body like acetone. Carbol, besides, not only yields no body like acetone on oxidation, but it is oxidized with great difficulty. It may also be recollected that the very existence of secondary alcohols is hardly established. We know as yet of but one secondary monatomic alcohol—the isopropylic—and from this one chemistry hardly can draw the data to establish the properties of a class. We conclude, then, that the hypothesis that carbol is an alcohol is inconsistent with known facts.

What, then, is carbol, and to what class do its analogies assign it? If not an acid, an aldehyde, nor an alcohol, what is it? Do we know of any class of bodies possessing the chemical relations of carbol? We do not. Scientific law, then, requires us to rank carbol by itself, to admit, at least for the present, the existence of a separate class of bodies of which it is the lowest member, and allows us, with Berthelot, generically to call this class—the Phenols.

There is reason for regarding carbol as benzene, in which one atom of hydrogen has been replaced by the water-residue OH. Thus:

$$\underset{\text{Benzene.}}{C_6H_5,H} + OH \text{ becomes } \underset{\text{Carbol.}}{C_6H_5,OH} + H.$$

In the same manner the homologues of carbol (cressol, etc.) arise from the homologues of benzene (toluene, etc.). Hence we say that the Phenol series arises from the Benzin series by substituting OH for H. We may notice, too, that it is possible in the Benzin series to replace two and even three atoms of H by two and three atoms of OH. So arise the biatomic and the triatomic Phenols.[1] These relations are most clearly set forth in the table below.

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[1] It will now appear why we prefer the word carbol to designate carbolic acid. In the first place, it is non-committal, involving no hypothesis. Then, it comes

Table of Benzins and Phenols.

	Benzins.	Phenols.		
		Monatomic.	Biatomic.	Triatomic.
1	Benzene, C_6H_5,H.	Carbol, C_6H_5,OH.	Pyro-catechin, Resorcin, Hydrochinon, $C_6H_4(OH)_2$.	Pyro-gallol (pyrogallic acid), Franguline, Phloro-glucine, $C_6H_3(OH)_3$.
2	Toluene, C_7H_7,H.	Cressol, C_7H_6,OH.	Homo-pyro-catechin, Orcin, Guajacol, $C_7H_6.(OH)_2$.	
3	Xylene, C_8H_9,H.	Phlorol (Xylol) ? C_8H_9,OH.	Beta-orcin, Veratrol, Kreosol, $C_8H_8(OH)_2$.	
4	Cumene, C_9H_{11},H.	Unknown.		
5	Cymene, $C_{10}H_{13}$,H.	Thymol, $C_{10}H_{13}$,OH.	Hydro-thymo-chinon? $C_{10}H_{12}(OH)_2$.[1]	
6	Unknown(?) $C_{11}H_{15}$,H.			
7	Unknown, $C_{12}H_{17}$,H.		Thymoilol, $C_{12}H_{16}(OH)_2$.	

Pyrocatechin and pyrogallic acid (properly, pyrogallol) have long been known, but only recently properly classified. Cressol is associated with carbol, and possesses all its properties, and according to Angus Smith (*Disinfectants*, p. 90), it is only a little inferior to carbolic acid in disinfecting power. It is supposed by Gladstone to be convertible into carbol by simple contact with zinc, or calcium chlorides.[2]

From orcin comes the litmus of commerce.

Guajacol (found in guaiac resin); veratrol (in seeds of *Veratrum sabadilla*), and kreosol, together with cressol and carbol, constitute the bulk of wood creasote.

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very near to the word originally proposed by Runge. If we use the word phenol (which has been proposed in lieu of carbolic acid) to designate the class, we shall need some other word to specify the individual. Carbol is a word constructed like the other phenols, as cressol, phlorol, etc.; it is euphonic, easily written, not liable especially in prescribing to be mistaken for anything else, readily convertible into a verb, or adjective, and not yet appropriated.

[1] Carstanjen in Journ. für Praktische Chem., No. 2, 1871.

[2] Chemical News, ii. 98.

Thymol, found in oil of thyme, has been used in surgery successfully as a substitute for carbol.

The whole truth does not appear in the above table. The formula of toluene we have represented thus: C_7H_7,H. It may be arranged thus: C_6H_5,CH_3. If we take the latter representation as a true expression, toluene is benzene C_6H_5,H in which H has been replaced by methyl CH_3. *Toluene was thus made in* 1864 *by Fittig & Tollens* (*Annal. Chem. Pharm.*, 131, p. 308). Thus: when mono-brom benzene is added to methyl bromide, and the mixture affected with sodium, bromide of sodium is formed, whilst benzene and methyl, meeting in the nascent state, unite to form methyl-benzene identical with the toluene found in coal tar or derived from balsam. Toluene is thus $C_6H_4 \left\{ \begin{matrix} H \\ CH_3 \end{matrix} \right.$, and toluol $C_6H_4 \left. \begin{matrix} \\ \\ \end{matrix} \right\} \begin{matrix} OH \\ CH_3 \end{matrix}$.

This process is of general applicability, and its application has thrown much light on all the bodies composing the aromatic series. It is the most interesting synthesis since Frankland first made ethyl. Other alcohol radicals, as well as methyl, may be used. Thus, if ethyl bromide is employed in the above process, xylene (phlorene) results, and from this phlorol (identical with the phlorol obtained from baric phloretinate by Hlasiwetz) is derived. By substituting amyl bromide for methyl bromide, Fittig & Tollens made amyl-benzene, which is No. 6 of the table, and marked unknown. They have shown that there are at least four isomeric bodies derivable from benzene having the composition of No. 5 of the table. Thus, tetra-methyl-benzene = $C_6H_2, (CH_3)_4$; di-methyl-ethyl-benzene = $C_6H_3, (CH_3)_2, C_2H_5$; methyl-propyl-benzene = $C_6H_4 (CH_3), C_3H_7$ (cymene), and butyl-benzene = C_6H_5,C_4H_9.

In commerce, carbol is always obtained from coal-tar, in which it is found associated with cressol, aniline, picoline, etc. The plan is to distil coal-tar, collecting the distillate of 150°–200° C., agitating this with soda lye, which, dissolving the carbol, cressol, etc., rises to the surface, and is removed, then decomposed with a mineral acid, and again distilled. The distillate of 184° C. is carbol of commerce. The details of the process, on which so much depends, each manufacturer keeps to himself, such secrets being stock in trade.[1] Carbol may be also obtained by distilling salicylic acid. This carbol is less deliquescent than the carbol of tar. Although carbol has not been made by direct oxidation of benzene, it can be obtained indirectly from that substance; for, when sulpho-benzene is fused with potash, potassic sulphite and carbol result. Berthelot has made the interesting observation that the vapours of alcohol, or acetic acid, passing through a red-hot tube, are in part converted into carbol.

It is pretty generally accepted that carbol precipitates albumen, and this supposed property of carbol has even been proposed for employment as a test for albumen in urine and the like, in place of nitric acid. Our results are opposed to this view. Sansom, too, declares (p. 11) that its power in this respect has been overestimated.

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[1] Consult Crace Calvert in Lancet for March, 1868.

When the albumen of egg or of serum is mixed with melted carbol, or even with 5 per cent. solution of carbol, the albumen is at once curdled, exactly as if strong alcohol had been added. The curds may be washed free from carbol, and will then putrefy under favourable conditions, just as any other coagulated albumen. Globulin behaves itself like albumen. A solution of albumen or globulin (from the crystalline lens), 1 per cent. strong, is not coagulated by any amount of a 1 per cent. or 2 per cent. carbol solution. A 3 per cent. carbol solution renders it opalescent, an opalescence which vanishes if more albumen solution is added. Not until a 5 per cent. solution of carbol is added does any coagulation take place. In the cold, carbol seems to be without action on albumen; for no matter how much the latter is in excess of the former, it is always possible to detect carbol by Berthelot's test, just as if so much water had been added, instead of the albumen solution. We consider it established: 1st. Carbol coagulates albumen by withdrawing its water. 2d. Carbol in the cold forms no compound with albumen.

There is a singular property of carbol, not before noticed we believe, which can properly find notice here. When albumen—as coagulated egg—is gently digested with melted carbol, it dissolves, forming a light yellow syrup. By addition of water to this syrup, albumen is precipitated, whilst, by the action of cold, the excess of carbol crystallizes out, leaving a rather bland brown syrup which tastes very feebly of carbol, and gradually dries into a transparent film not acted on by water. If the syrup is boiled, the excess of carbol passes off, and the liquid on cooling gelatinizes, becoming brown. Exposed to the atmosphere this jelly becomes white, the change seeming to commence at the centre of the mass, an efflorescence of carbol (?) crystals will also be found. After a while this whiteness disappears, the mass becoming transparent again as it loses water until it dries into a hard lump looking like a piece of copal. It gives evidence of the presence of carbol six months after its first exposure to the air, and although subjected to rain, wind, sunshine, damp, heat, and cold, it neither putrefies nor moulds. Fibrine, casein, or globulin, may be substituted for albumen.

The white spot on the skin produced by creasote or carbol, has been noticed for a long time, and has been referred to a coagulation of the albumen of the skin. But this is not the whole truth. In a few minutes after the appearance of the white spot, it begins to fade, and in an hour has disappeared. The white spot is caused by a coagulation of albumen, *and* by a contraction of the capillaries of the part. The disappearance of the white spot is caused by the dilatation which succeeds the contraction of the capillaries (with, of course, more or less reddening), by the solution of the albumen coagulated in the serum which is poured out under the skin forming a wheal, and by the power of carbol itself to render a mass of white albumen transparent by prolonged action.

By aid of heat carbol can, apparently, be made to combine with albumen. Thus: Blood serum was acted on by the reagents named, boiled, the coagula thoroughly washed, dried, and weighed.

	Grammes.
20 cc. of blood serum mixed with 20 cc. melted carbol, washed coagula	=1.460
20 cc. " " " " 5 cc. nitric acid " "	= .786
20 cc. " " " " 40 cc. 5 per cent. carbol " "	= .902
20 cc. " " " " 40 cc. 2 per cent. " "	= .857

Egg albumen was diluted with three parts water: 20 cc. contained .5565 grammes.

	Grammes.
20 cc. of albumen solution + 10 cc. 5 p. c. carbol solution evaporated dried at 200° C.	=.5960
20 cc. " " " + 20 cc. " " "	= 5825
20 cc. " " " + 30 cc. " " "	=.6210
20 cc. " " " + 60 cc. " " "	=.6250

A more dilute solution of albumen, in which 40 cc. contained .4555 grammes, yielded these results:—

	Grammes.
40 cc. weak albumen solution + 10 cc. 5 p. c. carbol solution evaporated and exposed to 200° C.	=.4680
40 cc. " " " + 20 cc. " "	=.5995
40 cc. " " " + 30 cc. " "	=.6320
40 cc. " " " + 60 cc. " "	=.5775

After these mixtures had evaporated to dryness at a temperature below 60° C. the residua were washed with water, and then dried for a long time in an oil bath at 200° C. No carbol could be detected after subjecting them to this process. These residua, so dried, presented the appearance of the dried films obtained from a solution of albumen in carbol. They readily decomposed, emitting a rotten odour.

Carbol solutions, as is well known, precipitate gelatine solutions only when these are concentrated, so that a precipitate occurring in a strong solution is at once dissolved on addition of water. The precipitation is due simply to obstruction of water. Prolonged boiling with carbol has no influence on gelatine. It neither unites with it, nor is its gelatinizing power impaired.

Carbol behaves differently with decomposing albumen or gelatine. We divided a solution of albumen into two equal parts. One part was placed in a glass-stoppered bottle, which it fitted exactly, and was placed on ice. The other portion was allowed to decompose, and in a few days was rotten. Equal bulks of carbol solution were now added to each albumen solution. After six hours' standing in closed vessels, carbol was readily enough detected (by Berthelot's test) in the sweet albumen solution, whilst it had totally disappeared in the rotten solution, and it was not until three more portions of carbol solution (equal in bulk and strength to that first employed) had been added to the latter, that it was possible to recognize free carbol in it. Evidently, the carbol in the latter had been acted on by some body which destroyed it, at the same time, probably, combining with it. The solution of rotten albumen, after it had received its four portions of carbol, lost its disagreeable odour to some extent. It was filtered, evaporated, and encouraged to crystallize, but no crystals formed, and it dried up into a friable mass. We may add that the sweet solution of albumen, which had received one portion of carbol, for a time underwent no change. The carbol, however, gradually disappeared, and the solution no longer reacted with heat and nitric acid, showing that the albumen had been changed. The solution became rotten. The explanation seems to be that carbol preserves a definite quantity of albumen from decomposition. If an insufficiency of carbol is added to a solution, a portion of the albumen may decompose. After decomposing, the carbol can unite with it. Hence a portion of the carbol disappears. This process being repeated, occasions the gradual but finally total disappearance of carbol, and then the remainder of the albumen decomposing, we have a rotten odour. Marvellously small quantities of carbol have been credited with preserving organic matters from decomposition. Thus Lemaire, in his chapter on the applications of phenic acid to preservation of anatomical material, recommends, p. 375, 1 per cent. solutions for injection, and says if the temperature does not exceed 20° C., the cadaver can be preserved for two months. If the temperature rises, he says, that this causes volatilization of the acid, and hence putrefaction results. Our explanation would be like that offered in the case of the sweet albuminous solution. The carbol, when injected in a 1 per cent. solution, at once combines with any decomposed albuminoids which we know have power to determine putrefaction in perfectly fresh albuminoid matters in their vicinity. Thus the predisposition to decay (if we may use the expression) is taken away. But as the body putrefies little by little, the carbol, combining with the degenerate albumen little by little, disappears, and after it has all been taken up or destroyed by the decomposing albumen, the albumen which remains, and which goes on to decompose, emits the usual rotten odour. The case would be different if 5 per cent. solutions were used. In this case the preservative property of carbol would consist in its power to abstract water and coagulate albumen. It would preserve just as alcohol does. Lemaire publishes a letter, p. 298, from M. Lambert, from which it appears that the firm of Lambert & Biraben, of Montevideo, had practically solved the problem of applying carbol to the preservation of beef without injuring its quality, and at a reasonable cost. The plan is to deprive the meat of as much water, bone, etc., as possible, then to compress it by a hydraulic engine, and then to bale it in canvas soaked in tar containing 20 per cent.

of carbol. As this was six or seven years ago, and as the plan has made no commercial demand for the beef so prepared, it is probable that some defect has been found in the process as to expense, etc., or in its results as to the vendibility of its products. Carbol does not possess the qualities which fit it for the use of the anatomist, as a substitute for alcohol. It cannot always be relied on to preserve a pathological specimen. Thus we lost, by relying on carbol, a uterus, etc., with the ovary dislocated into the cul de sac. Although the specimen was thoroughly covered with a 5 per cent. carbol solution, in a tight vessel, it decomposed, and, in two weeks, was swarming with maggots; the parts were infiltrated with pus, and had not been placed in the jar immediately after removal from the body. Lemaire would explain this by the presence of the large quantity of pus. Pus contains oil in notable quantity, this oil should dissolve the carbol, and he has shown (and Sansom also) that oil greatly diminishes all the powers of carbol. Indeed, the former writer, at p. 384, quotes Gratiolet to the effect that carbol will not preserve crabs from decomposition, because these animals are possessed of a very large liver full of oleaginous material. We attributed the loss of the specimen to the excessive quantity of decomposed albuminoid matter with which the carbol was at once neutralized.

We added carbol, liquefied by heat and moisture, to butyric, valerianic, acetic, formic, and lactic acids, to the essences of apples, pears, and pineapples, to decomposing leucine, to phosphuretted and sulphuretted waters, with and without ammonia, to propylamine, to benzene, acrolein, assafœtida, and onion-juice, to oils of cognac, citronella, peppermint, bergamot, and turpentine, and to the liquid of horrible and penetrating odour arising in the manufacture of tyrosine by the action of potash on albumen. In none of these cases was there any diminution of odour. Usually, the feeble carbol odour was quite extinguished. The following comparative experiment was made:—

1 gramme rotten pancreas was mixed with	1	per cent.	melted carbol	(1.)
" " " "	5	"	" "	(2.)
" " " "	10	"	" "	(3.)
" " " "	1	"	zinc chloride dissolved	(4.)
" " " "	5	"	" "	(5.)
" " " "	10	"	" "	(6.)
" " " "	1	"	potassic permanganate	(7.)
" " " "	5	"	" "	(8.)
" " " "	10	"	" "	(9.)
" " " "	1	"	bleaching powder	(10.)
" " " "	5	"	" "	(11.)
" " " "	10	"	" "	(12.)

Nos. 1, 2, 3, 4, and 5 were not deodorized. Nos. 6 and 7 were nearly deodorized—8 and 9 perfectly deodorized. In 10 the odour was diminished. Nos. 11 and 12 smelt of bleaching powder only. Neither in

Lemaire's nor in Sansom's works can we find experiments similar to the above, although the latter author attributes great deodorizing power to carbol. Lemaire, however, p. 337, "Disinfection," substantially declares that carbol is not a deodorizer. Our experiments support the latter opinion.

Little is known of a definite nature respecting the disinfecting powers of carbol. The subject is an extensive one, and difficult to handle. Lemaire and Sansom content themselves with assuming that putrefaction is due to germs, carbol kills all germs, so that it *must* be a disinfectant. Thus, Sansom says, p. 20, "All disinfectants act in virtue of and in proportion to their power as septicides." Admit this, and the case for carbol is made out. Unfortunately, evidence of this kind is about all that we are likely to get. Is it not better to confess ignorance at once?

Parkes, at Netley, conducted for the British War Office a series of experiments to determine the position of disinfectants in power, cost, etc. His results are, on the whole, unfavourable to the extensive use of carbol, for though first in power, it was greatest in cost. He found that sixty grains were required to disinfect the excreta of the twenty-four hours of an individual. Lemaire "disinfected" (?) a privy containing 15,000 litres of ordure by 200 grammes of carbol (*De l'Acide Phénique*, p. 339). Parkes, in his experiments at Netley, found that whilst he was made sick (having fever, furred tongue, headache, and changed pulse) by inhaling the odours from ordinary sewage, that this did not occur if the sewage had previously been affected with carbol. This is certainly very much to the purpose, so far as it goes. Compare such an experiment, however, with the demonstration made in our own navy, that yellow fever can be exterminated by battening down hatches, and turning superheated steam into the hold. In the latter case, the result was conclusive beyond all peradventure, 1st, that the poison of yellow fever is neutralized by superheated steam, and, 2d, that superheated steam can be used for this purpose. Who would care to exchange superheated steam for carbol in a vessel infected with yellow fever?[1]

In the application of carbol to hospital disinfection (we mean the freeing a hospital of the poisons of erysipelas, puerperal fever, and the like, and not the destroying of a mere odour), but little has been done; and we fail to see how more definite conclusions can be reached than were adopted by Dr. Russell, at the Glasgow Fever Hospital, who, after a patient use of carbol as a disinfectant in the wards of that institution, declares, "As to the practical benefit of this process, I am unable to state that this or that has been the result." (*Glasgow Medical Journal*, February, 1869, p. 210, quoted in *Braithwaite* for July, 1869.)

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[1] Scepticism as to the disinfecting powers of carbol surely requires no apology after the spectacle of a large steamer—the Franklin—having case after case of cholera on it, to the number of a hundred (although it had touched at a port where plenty of carbol could have been obtained), and continuing to be infected after reaching New York, so that the surgeon and others died. If carbol is a disinfectant, why was it not used to stamp out the disease on its first appearance? It is hard to imagine a case more suitable for its application, or where its use would more certainly have exterminated the infection—if it is possessed of the power so unwarrantably accorded to it. Here was a chance for a crucial experiment worth more than the assertions of all the Boards of Health in the world that so "many pounds of carbolic acid have been used in the late epidemic."

We think that Dr. Russell's experience will be that of every one who uses carbol to "improve the air" of a hospital; and whether it would be right to experiment with this substance for the cleansing of wards from pyæmia, erysipelas, puerperal and yellow fever, etc., whilst we have such a powerful destroyer in superheated steam, belongs to ethics. It is in the application of carbol to the cleansing of wards, ships, etc., so polluted, that the solution of the question lies, and certainly there must be plenty of opportunities for testing the powers of carbol of destroying persisting contagion, in which steam is inapplicable. It is difficult to overestimate the importance of this matter. Meanwhile, however, we may experiment, and draw inferences therefrom as to the disinfecting powers of carbol. Thus, experiments on an extended scale might be made with smallpox, and vaccine virus, affecting these poisons with varied but *definite* carbol solutions, as carbol in oil, of one to twenty per cent., in glycerine, syrup, etc. Aqueous solutions of carbol, from one-half to three per cent., should be studied in this relation, and these same strengths after the carbol solutions have been acted on with sweet and with rotten albumen—this to determine whether it acts by killing organisms or by combining with those degenerate educts of the animal body which are at once the home and the food of the contagion. The poisons of glanders, hydrophobia, and even of syphilis, might afford adjunct experiments as a check upon the above.

Having settled the question for these tangible contagions, on which we can experiment so accurately and demonstrate so clearly, we might be justified in extending our conclusions to the more inscrutable contagions—cholera, typhus, and the like. At all events, pending the grand proof (to be obtained only by the successful use of carbol in practice against definite contagions), our faith in carbol as a disinfectant would rest on something like a definite foundation. As it is, we must use carbol without purpose, perhaps without confidence, feeling all the while that we may be neglecting other certainly potent disinfectants (steam, nitrous acid), merely to be in the fashion.

We have made a few experiments to determine whether carbol in aqueous solution will destroy the poison of vaccine. We powdered a healthy scab of fresh vaccine, and divided the powder into three parts, two of which were hermetically sealed in glass tubes. The other portion was affected with two per cent. solution of carbol—enough to make a syrupy liquid. With the lymph so prepared we vaccinated eight unprotected infants. Vaccination failed in all. The second tube was then opened, and affected with one per cent. carbol solution. Three out of four of the eight upon whom the first trial was unsuccessful, were vaccinated successfully. The other tube was opened and mixed with water, and the four remaining infants vaccinated. Of these four, only one was successful. Some five per cent. carbol solution was then affected with rotten serum, in such a way that after filtration the filtrate contained two per cent. of altered and unaltered carbol. With this was mixed some of the powder of the last opened tube, and a man who bore such faint marks of vaccination as to leave the question of his safety in doubt, was inoculated. A spurious vaccination resulted, showing that the vaccine power was unaltered, but the man after all protected.

Before concluding this part of our subject, we must notice, at least briefly, the employment of carbol in rinderpest. Thus, according to Crookes, certain farms in the track of the plague enjoyed immunity by using vapour of carbol disseminated throughout the stable. By way of experiment, a healthy beast was placed near one affected with the disease—the atmosphere of the stable being charged with vapour of carbol *and* of sulphurous acid gas. The healthy beast remained healthy for a month. A second experiment was not so favourable, for the sound beast died on the thirteenth day of the exposure. We may remark here that the interpolation of the sulphurous acid gas was improper, if it was intended to make a fair experiment on the powers of carbol. Again : he records that the disease was checked on a farm where it was raging in its usual course, by the free use of carbol *and* sulphurous acid gas. On another farm, the cattle having been divided into two lots, one lot, forty-five in number, was placed in stables treated with carbol *and* sulphurous acid gas. The other lot, twenty-eight in number, was placed in stables not so treated. The disease was accidentally brought by inoculation into both lots. In the first-mentioned lot (protected), only those individuals who were inoculated took the disease. In the second lot, all took the disease, and all died. Mr. Wm. Hope, who has had great experience in the disease, says, of a herd of two hundred and sixty cows, treated on the " carbolic acid plan" (by carbol and sulphurous acid gas ?) at Crookes's suggestion, that he saved every one of which he took charge, whilst those not under his care died or were slaughtered. (Sansom, *Antiseptic System*, p. 132, quoted from *Chemical News* for Oct. 1870.) We cannot attach the value accorded by Sansom to these observations, as regards the disinfecting power of carbol ; and certainly the fact of employment of sulphurous acid gas shows that Crookes did not place unlimited confidence in the powers of carbol.

Cases are recorded by a French Commission appointed by the Minister of Agriculture, of the successful use *internally* of carbol, in charbon, and furuncular epidemic. (See summary in *Lancet* for May, 1869, p. 276.)

We stand, therefore, in about the same position as in 1863, when Lemaire declared that if epidemics are caused by living germs, phenic acid should prove their destruction, cholera and other epidemics thus finding in the acid a sure cure. (*De l'Acide Phénique*, p. 362.)

Of all the elemental forms, pus and lymph are the most susceptible of changes produced by carbol. Pus is precipitated readily even by one-half per cent. solution of carbol. When a drop of mixture of one per cent. carbol solution and pus is examined under a quarter-inch objective, it will be found that all cells are destroyed, their contents uniting with the carbol to form gelatinous islets, which float in a yellowish liquid. These islets are studded with granular matter. If the microscopic stage is inclined, these islets elongate, and present the appearance of ganglionic cells under a high power. If tested chemically, it will be found that the carbol has disappeared. If excess of carbol (as demonstrated by chemical tests) be added, the islets dissolve, save the granules, and we find simply a yellow liquid with granules floating in it. With pus, as found in wounds, carbol at once unites, and the two bodies dry up into a hard oily crust.

It has been stated that carbol is without action on blood corpuscles. (*Lemaire Acide Phénique*, p. 100.) Lemaire, however, does not seem to have examined the action very carefully or out of the body. The elliptical cell of birds is best adapted for examination. Thus in the blood of the common fowl, in a very thin clot under a quarter-inch, we shall find a quantity of rice-shaped cells each with a black spot in its centre. If a little 1 per cent. carbol be placed on the slide just touching the clot so as to make the action of the carbol as gradual as possible, in the course of the carbol current we will first notice a few broken-up cells (not the true corpuscles) which blacken and shrivel up as the amount of carbol increases. Presently, however, we will find the true blood corpuscles attacked. They become smaller and rounder, darker, and at last polygonal. At first they occupied the whole field, now they are so shrunken (and destroyed?) that wide spaces exist between each cell, spaces filled with a glairy liquid. In some of the cells the black spot is seen to divide, and each half to take up a new position at the ends of the cell, the cell wall at the same time contracting in the middle, though never to complete fission. Finally, such cells as have not been dissolved (?) vanish by sinking out of focus, for, on lowering the objective, they will be found lying flat on the slide. Exactly these phenomena may be observed with human blood, although in a less degree. A 3 per cent. solution of carbol intensifies the action, but, at the same time, confuses it by its rapidity and by its action on the serum.

When the juice from the testicle of the common cock is examined under a quarter-inch objective, we will find (1) spindle-shaped cells, each containing an eel-like form, which by its contortions changes the shape of the cell incessantly. These are the "vesicles of evolution" of Wagner. (2)

Small spermatozoa like those of man and mammals, but smaller. (3) The eel-like bodies released from the "vesicles of evolution."[1]

A drop of this semen affected with $\frac{1}{2}$ per cent. solution of carbol, applied as in the case of the blood-cells, failed to arrest the motion of (1), (2), or (3). One drop of 1 per cent. solution was also without effect, but two drops stopped all motion in (3); two drops of water had the same effect. A very small drop of 2 per cent. solution stopped motion in (3), but was without this action, at least for a time, on (1) and (2). A 4 per cent. solution did not entirely check motion in (1) nor in (2), though its activity was diminished. No. 3 became sharply outlined, as were the contents of (1); the cell of No. 1 began to contract. A drop of 5 per cent. solution checked motion in all three. Under its influence (1) became smaller, whilst (2) became greatly enlarged (two or three times). The cell walls of (1) were much more distinct, and the liquid in which the bodies floated thinner. On mammal semen (that of the cat errotically excited) carbol has a more decided effect. Even $\frac{1}{2}$ per cent. solutions check motion in the spermatozoa at once. It should be remembered, however, that water has the same effect. By 4 per cent. solutions the spermatozoa were enlarged and better defined and not otherwise changed. The medical jurist may find this action of carbol of practical importance in pronouncing on supposed seminal spots.

White and yellow fibrous tissue are attacked by carbol solutions slowly if these are dilute, more rapidly if concentrated. The fibres become disintegrated, assuming a granular or perhaps a worm-eaten appearance. Still, neither white nor yellow fibrous tissue dissolves in saturated carbol, even when kept for weeks at a temperature of 40° C. On muscle fibre carbol (1 per cent.) has little effect; the striæ become more distinct in consequence of a general deepening of the colour. By 4 per cent. solutions the bundles become very dark and show a disposition to split up, and the carbol besides seems to exercise some solvent power on the ends of the bundles especially.

We have expended a great deal of time and work on the action of carbol on the nervous structures, but with poor result so far as discovering any specific chemical or mechanical action sufficient to account for the marked influence (which we shall prove) carbol exerts over the nervous system. By 1 per cent. solutions the cells and their nuclei are rendered more distinct, and this is true of the walls of the tubules. Stronger solutions destroy the cells, possibly owing to the affinity of carbol for oil. However this may be, the fluid becomes filled with oil globules and cell debris floating in a thin liquid. The white substance of the nerve tubule seems to be dissolved, and vanishes.

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[1] These observations were made on two cocks in the early spring, when the generative energy is strongest. The small spermatozoa (2) are not noticed by Wagner, at least not in his article on Semen in the *Cyclopædia of Anatomy*. We are at a loss to know what they are; only of their presence are we certain.

On milk 1 per cent. solutions are without effect, whilst 2 per cent. solutions render the microscopic field hazy. A complete coagulation of the casein, albumen, etc. occurs with 5 per cent. solutions. All aqueous solutions of carbol are without action on the globules. Carbol liquefied dilates the globules, but does not destroy them. Milk so affected has the appearance of white paint.

When a quantity of liquefied carbol is retained in contact with the skin for two or three minutes, the first noticeable phenomenon is the occurrence of the white spot. This presently becomes surrounded with a halo of congestion. Next serum commences to be effused, so that the skin is raised in a wheal. The smarting which was present at first now subsides, and in place thereof anæsthesia over that portion of the skin covered by the white spot begins. The surrounding congested parts are hyperæsthetic. This anæsthesia is at its height in fifteen or twenty minutes, and involves the whole dermal envelope down to the cellular tissue. The skin so affected may be punctured, cut, or burnt without sensation. A previous soaking of the parts in dilute acetic acid increases the power of the carbol to penetrate. As we have in a previous paper[1] shown how this power of carbol can be applied to operative surgery, we will not dwell longer on this point than to remark that a continued use of carbol as an anæsthetic in operations requiring only the incision of the skin has established our first confidence in it for this purpose. To deep-seated buboes, etc., where the inflammation and tenderness are seated chiefly in structures below the skin, it is not applicable. We think, too, there is something in this use of carbol which predisposes to a very rapid healing of the incision so made, for over and over again such incisions have healed without leaving any cicatrix. This was true, for instance, in two operations for epithelioma, in which a V-shaped piece of the lower lip was removed. In both cases pain was felt, though certainly in a lessened degree—about as much, for instance, as when ether spray is used. Solutions of carbol in glycerine have no anæsthetic, or, so far as we could discern, other effect, when applied to the skin. Solutions in oil are less powerful than aqueous solutions, and for various reasons are not advisable for producing anæsthesia, unless for the purpose of injecting a sinus or a gunshot wound, when they are much better than aqueous solutions, provided the strength is not less than 1 : 10. Solutions of carbol in acetic acid have very powerful anæsthetic effect, but the incisions heal badly, and even if the solution is applied to sound skin an abscess is very apt to result. This we state from actual observation.

The white spot gradually fades, the place becoming brown red, and the serum disappears about the same time. After a few days this brown redness is succeeded by a tallow-like whiteness, and this is surrounded by a halo of fiery redness, like the line of demarcation in gangrene. Still the skin so affected does not gangrene, but dries up, cracks, and is pushed off by newly formed structures beneath. Then the surrounding redness fades, and in a period of from ten days to a fortnight all trace of the action of carbol has disappeared. A 5 per cent. solution, aqueous or ethereal, if confined to a spot, and prevented from evaporating, produces similar though less pronounced effects.

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[1] Am. Journ. Med. Sciences, Oct. 1870, p. 573.

If we touch the wing of a bat with 5 per cent. solution of carbol, we will observe: 1st. A contraction of the capillaries and small arteries; 2d. Complete arrest of the circulation; 3d. Effusion of colouring matter, with coagulation. This effusion constitutes a solid clot on the *outside* of the vessels, for in a short time the vessels dilate again, and the circulation is resumed, whilst the clot remains. These effused products remain, at least in the human body, for a long time, undergoing apparently the same changes as we notice occurring in the case of a bruise. Finally only a feebly yellow trace remains, surrounding the spot where the carbol had been applied, but not invading it: this yellowness is permanent in some cases. The hair follicles are usually left uninjured.

Although creasote has been used for a long time as an application to burns, and even ulcers, yet to Lemaire belongs the credit of applying the chief constituent of creasote—carbol—with the definite purpose of preventing gangrene, ulcerations, etc., by killing the germs he believed were causative of these lapses of nutrition. Thus he applied it in anthrax, having discovered in the pus from that disease animalculæ, and with the intention, we infer, of killing the germs to which he attributes anthrax. (*Acide Phénique*, p. 452.) He used it in ulcerations, abscess, cancers, besides in various skin diseases, especially those of a parasitical origin. His theory stands forth in his practice against the more hidden internal disorders, as intermittent fever.

Curiously enough, shortly after the appearance of Lemaire's second edition in 1865, Lister, from similar theoretical considerations, announced substantially the same facts regarding carbol, and inaugurated what he called the antiseptic system. Lister has, perhaps, had greater opportunities for carrying out Lemaire's notions, and in doing so has developed and improved them as regards their practical applications. Could we but admit this evil agency of germs, Lemaire's and Lister's practice would follow as a necessary consequence. As it is in consequence of that adherence to this theory, the value of their observations diminish as their enthusiasm increases. Since Lister inaugurated the antiseptic system in Glasgow, he seems to have devoted himself to its perfection. He has tried every imaginable device for debarring germs from wounds, or for killing them after their entrance. Considering the advantages which we may derive from the use of carbol in wounds, which we undoubtedly owe to Lister, as well as his constancy and consistency to his first idea, although refusing his theory, we cannot withhold, whilst accepting his practice, our small testimony of praise and admiration.

Listér publishes, in the *Lancet* for April, 1870, the result of the practice of the antiseptic system at the Glasgow Infirmary, claiming, and correctly for aught that has been disproved, a reduction of mortality, in major operations and compound fractures, from 1 in 2, as it was before the use of carbol, to 1 in 6. This reduction is due, he says, to prevention of pyæmia, and possibly hospital gangrene and erysipelas. We can readily admit that carbol reduces the chances of pyæmia (and hospital gangrene?). Lister, we think, fails to show any reduction of erysipelas. But in admitting the power of carbol to prevent pyæmia, we furnish no argument for Lister's pet theory. Pyæmia supposes pus. Carbol prevents the formation of pus. No pus, no pyæmia. This is the conclusion *we* draw from the papers referred to.

Lister's successes have been confirmed by the practice of many others. Bottini, of Novara, reports on six hundred wounds treated by carbol. He declares it prevents suppuration, and promotes cicatrization. (*Brit. Med. Journal*, June, 1867.) Lemaire noticed this effect, and records his faith in the power of carbol to prevent suppuration repeatedly; thus *De l'Acide Phênique*, p. 477; on Cancer, p. 490; Epithelioma, p. 602; Necrosis, etc. etc. Most of the medical journals for the last five years have contained papers detailing the successful use of carbol in wounds, recounting an experience usually of five or six cases each, but almost always remarking on the unique power possessed by carbol of restraining suppuration. Carbol, however, is no specific. Some have failed in its use (if we accept Lister's statement, because they have not applied it thoroughly, we submit because it is not adapted to every wound), and have rejected it in consequence. The aggresssive way in which Lister brought forward carbol provoked a good deal of opposition, the surgeons of some of the London hospitals prejudging the question. Dr. Morton, of Glasgow, opposes it in a paper (an abstract of which may be found in the *Lancet* for May, 1870), citing cases of the failure of carbol to prevent suppuration, besides the occurrence of erysipelas under its use. His opinions would carry more weight if they displayed less of a partisan influence.

Time will show, if it has not yet shown, that the estimate of Mr. Wood, of King's College Hospital, London, comes nearest to the truth. He declares that, "whilst carbol did well applied to wounds in a hospital in good sanitary condition, it was without effect in averting those disasters which befall the wounded in a hospital, the air of which is vitiated." (*Lancet*, March, 1869.)

Our experience in the use of carbol has been comparatively limited, but that little has sufficed to convince us that carbol has a power possessed by no other known remedy of preventing or of arresting inflammation in most cases. Although our success in its use has not been unfailing, we have obtained such excellent results in several apparently desperate injuries occurring in our service in St. Joseph's Hospital in this place, that we are now accustomed to go to any operation with the feeling that, whatever else may betide, we can arrest inflammation. We will not occupy space in detailing cases; suffice it to say we have used carbol in the major amputations, as of the thigh and arm, deligation of large arteries, as the carotid, extensive gunshot wounds of both thigh and leg, compound fractures of thigh, and in particular in a case in which nearly the whole of the frontal bone was lost by necrosis, the result of an accident; perhaps twenty-five or thirty cases in all. The cases in which carbol did badly were five or six in number, and of a lesser seriousness.

The question "Why does carbol sometimes fail?" presented itself to us at an early period of its employment, and our observation has satisfied us that this failure is due to causes connected with the patient's general health. The wounds of those patients who require alcohol and bark do badly under carbol. In these cases carbol not only fails to arrest, but it even seems to aggravate, the inflammation. Carbol, therefore, is an experiment in every case. Our rule for its use is, if inflammation, as manifested by suppuration, is not checked within twenty-four hours, to abandon it at once, and administer supporting internal treatment and poultices locally. We may add that most of the cases in which carbol did badly were wounds of hand or fingers, its tendency seeming to be to start inflammation up the sheath of the tendons, forming abscesses in the palm or at the wrist. Here an immediate removal of carbolized dressings, the free use of whiskey and cinchona, and poultices, brought about a favourable change. Other wounds of hand and fingers have done well under carbol.

But there is another object to be gained by the use of carbol as a surgical dressing, besides that of averting inflammation. This is the procurement of quiet and comfort to the patient by the anæsthesia resulting. Thus, in a case of necrosis of the upper jaw, attended with exquisite sensibility to instrumentation, by the judicious use of carbolized oil (1 : 7 by measure) on lint, and injected by a syringe, we finally obtained so much insensibility that the necessary operative procedures, repeated many times, were little complained of. The pain of compound fractures rapidly disappears under its use. Balls may be searched for with best advantage after the use of carbol. Thus, in a case of gunshot of the tibia (a pistol ball entering at the popliteal space ranging forward and downward) with abscess in the head of that bone, which we had trephined under ether, it was impossible to use the probe without resorting to general anæsthesia. The free use of carbol for twenty-four hours not only changed the whole aspect of the case, but allowed us to make such a free use of the probe and scoop for nearly an hour, that we finally discovered the ball half way down the cavity of the tibia, and readily scooped it out.

We have had one case at St. Joseph's Hospital in which carbol seemed to be the exciting cause of erysipelas. The case was one of ununited fracture of the tibia, and we had carried a strand of silk threads soaked in melted carbol through the ends of the bones, using carbol, by the way, at the point of entry and exit of the drill as an anæsthetic, the patient feeling little pain throughout the operation. On the third day, erysipelas commenced at both punctures, and soon had involved the whole leg and part of the thigh, so that energetic means were required to save the limb.

We lost a private patient from pyæmia whilst under carbol treatment. The case was one of adherent prepuce and urethral stricture. We had dissected off the prepuce, and dressed the wound with carbolized oil, under which it did badly; and we changed it after the third day for tartrate of iron and potash locally, and whiskey and bark internally. On this day the man had a chill. He was labouring under chill and fever at the time of the operation, and we therefore ordered quinia, which, after he had several more chills, seemed to arrest the disease. In about a week, we returned to the carbolized dressing, as the suppuration was too free, and the wound progressed pretty well, and finally healed. Before doing so, the man had more rigors, complained of pains in shoulders, then in his knees, etc. An abscess formed in his thigh as large as a hen's egg, and a deep ulcer remained, which ultimately healed under carbolized dressing.

Six weeks after the operation the scrotum began to swell, and presently was infiltrated with little abscesses, which finally determined the gangrene of the whole scrotum, and the lower part of the tissues of the abdomen. Pus was found after death in the knee and shoulder joints, and in most of the viscera. He had no urinary infiltration, and we had no doubt that death resulted from pyæmia.

In the practical application of carbol, our usual plan after an operation is to wash the wound thoroughly with 5 per cent. aqueous solution of carbol by means of an ordinary chemical wash bottle. Then cerate, or oil carbolized 1 : 10, is applied in as great excess as possible. Stitches are then put in (which may or may not be carbolized by soaking in liquefied carbol); and on the line of the wound, silk gauze soaked in carbolized collodion 1 : 10 is spread. After which the parts, especially if it be an amputation, are put away in plenty of oakum. In using carbol on a granulating surface, there is one fact of importance to be noticed. There comes a time in the healing of wounds under carbolized dressing, when it does harm. This happens at the period of commencing cicatrization. The dermal substitute will not form under the action of carbol. The strength of the carbol dressing must then be greatly reduced, or substituted by simple oil or water. The desired action of the granulations soon commences, and the cure is not delayed.

In parting with this portion of our subject, we express the conviction that if a surgeon, in using carbol as a dressing, *could* convince himself that there are in wounds germs hostile to healing, to be successfully encountered only by the most liberal use of carbol, he would have no cause to regret his practice, whatever others might say of his theory.

It will be noticed that the cause which Lister assigns for unhealthy action in wounds is entirely objective. No one will deny that there are objective causes for unhealthiness of wounds, and germs *may* be one cause. But it is certain that in the vast majority of wounds, the cause of unhealthiness springs from within—is subjective. This is the established faith of the medical profession. Hence has arisen the classification of wounds into syphilitic, scrofulous, scorbutic. Hence the care of all surgeons before all great operations, to place their patients in as good a state of health as possible. Hence the fatality of operations in the gouty, scrofulous, and scorbutic; in the drunkard, the glutton, even in the plethoric, or in the obese. Can this experience of the past and present be all wrong? It may be asked, If Lister is right in his theory, whence come abscess of prostate, and the pyæmia sometimes attendant? Whence psoas abscess? How is it that abscess of lung tissue is so rare, considering the excessive accessibility of the lung to the entrance of the germs? Why is carbuncle of the lip more apt to end in pyæmia than almost any other accident, if pyæmia is the result of germs? Why should germs infect pus more certainly in this situation than the pus of a carbuncle on the shoulders? Why is it that chloride of zinc, aniline, and dilute sulphuric acid, all powerful septicides, have no power over inflammation like carbol? Lemaire, Liston, and Sansom, as we have before remarked, all seem quite as much interested in using carbol to prop up the germ theory as to cure disease. Pointing to the excellent results, they ask how can you explain these results more simply and conclusively than by admitting that carbol acts in these cases solely by its germ-destroying power? This is no argument, although really advanced by all three as such. It may be met and answered by silence, or it may be shown that some other theory will account for the facts in the case quite as well. To this end, and not because we attach any value to it, we offer an explanation, founded on the anæsthetic power of carbol. Our explanation, if not absolutely true, we believe to be in the *direction of the truth,* making, as it does, the causes for unhealthy action purely subjective.

The action of carbol in subduing inflammation is manifold. First, carbol breaks up all foreign organized bodies like pus, destroying their pseudo-life, and preventing the mischief which results from that life.

Secondly, carbol combines with decomposing albuminoids whose presence and contact tend to induce the decomposition of healthy albuminoids in their vicinity, thus becoming never-ceasing sources of irritation. Finally, as we have shown and others have confirmed, carbol suspends nerve irritability, producing anæsthesia, and, as Lemaire has noticed, also paralysis. It is to this property of carbol that we attribute its peculiar power over local inflammation. Carbol renders the nerves incapable of transmitting impressions of pain, and *probably* those impressions also which are concerned in the nourishment or repair of tissue. The probability here involved is a strong one. Not only clinical experience but experiments have taught us that the nervous influence, although not essential to nutrition, "may, and even almost constantly does, influence nutrition and secretion,"[1] and that both afferent and efferent nerves of nutrition must exist just as we can prove that the same or similar nerves preside over secretion. Thus, if we touch the periphery of an afferent nerve distributed to a gland, although this nerve carries no sensation of which we are conscious—as of pain—yet that some impression is carried we cannot be doubtful, for the gland is thrown into action. But other irritations excite the gland, and among others that irritant coeval or identical with the condition which calls for the secretion or other action of the gland, and which we may call the physiological irritant. Thus dryness of the fauces is the physiological irritant which originates action in the salivary glands. The analogy from secretion to nutrition is perfect. Exactly these sequences are concerned in the nutrition and repair of every tissue. We are unconscious of them, for it is not the nerves of common sensibility (or at least their function of common sensibility) that are involved. We know that information is carried to the ganglion presiding over the nutrition of the part that certain materials or forces must be sent out to enable the cells to maintain their flagging energy or threatened integrity, or even (if there is a wound) to heal a breach. There is nothing new in all this; it is the view of Brown-Séquard and others, and we may say generally accepted by physiologists. There is a happy state of wounds, a state (as in ordinary healthy nutrition) in which the calls or requisitions for force and materials needed for repair, sent over the afferent nerves, are not exaggerated. Here no excessive supplies of force and materials are sent out in response. The repair is made without inflammation; it is the repair of immediate union. The force is not exaggerated; there is no heat, the materials are exactly equal to the needs; there is therefore no redness nor swelling, and without heat, redness, or swelling, there is no pain; in short, as we have stated, no inflammation. But usually this happy state of things does not obtain. The afferent nerves carry exaggerated reports of the mischief, which become exaggerated requisitions for force and materials. The presiding ganglion responds accordingly; the efferent nerves bear exaggerated influences to the vessels (or the nerves of the vessels), and to the cells, and we have excessive action, with the symptoms of heat, redness, swelling, and pain. We find that carbol prevents inflammation, that it prevents certain nerves from carrying impressions of pain, certain others from carrying the expressions of the will (according to observation of Lemaire). We submit, then, that it is not unreasonable to conclude that carbol prevents inflammation by checking or suspending the susceptibility of the nerves of nutrition to their irritants, and so moderating, if not altogether preventing, requisitions on the presiding ganglion, that no exaggerated force is sent forth, and no excessive action takes place.

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[1] Consult Brown-Séquard's Lectures on Functional Nervous Affections, pp. 11–23.

These views are consistent with the promptness of carbol in subduing inflammation, with the circumstance that in certain cases of low or perverted vitality caused by constitutional depression, it acts badly, with the fact that it interferes with, instead of promoting, cicatrization (the parts by the time this stage has been reached being in nearly the condition of ordinary nutrition, and, therefore, instead of repression of action, requiring stimulation), and with the fact that another anæsthetic, morphia (as reputed by the best authorities), also subdues or prevents inflammation.[1]

The theoretical views of Lister have, we think, led to positive mischief in the matter of the antiseptic ligature of arteries. In *The Lancet* for June, 1869, Lister has shown that a bit of catgut or peritoneal membrane twisted into a thread, soaked for some time in carbolized oil, and tied around an artery, undergoes curious changes, and is converted finally, according to his observation, into a "living ligature," firmly encompassing the artery at the point of deligation. Lister's experiments were conducted on the calf. He does not seem to have tried ordinary catgut, and it is to be regretted, for, had he done so, and made more numerous experiments, examining the ligature in one animal at the end of two weeks, in another at the end of three weeks, and so on, he could not have failed to find what the "living ligature" really is. Lister has tied several arteries for disease on this plan, and has met with more than one imitator. Most of the cases reported have been successful, and for the iliacs in their whole course we should prefer the carbolized ligature. A case has been placed on record by Mr. Spence, which satisfies us that the plan is unsafe in all amputations, and in ligation of the carotid. In other ligations than those named, we fail to see that it has advantages over the time-honoured silk. Mr. Spence's case was a ligation of the carotid below the omo-hyoid. He followed out Lister's directions most exactly. On the day after the operation the patient, immediately after a fit of vomiting, became paralyzed, and ultimately comatose, in which state he died on the third day. It was found after death, that the ligature had broken (dissolved would be the better expression), and had allowed the clot which had formed in the carotid to slip up into and plug the middle cerebral artery. Mr. Spence says:—

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[1] From the peculiar action exercised by carbol on the nervous system, and especially from its power of diminishing local nerve irritability, we anticipate that its extended use in wounds will diminish the number of cases of tetanus therefrom resulting and decrease the mortality from this affliction. No one seems to be on the lookout for this result, and, indeed, it is only in tropical regions, where tetanus is such a frequent complication of wounds, that observations on this point can be made.

> "On looking at the ligature with a pocket lens, the texture of the catgut was distinctly seen, but it was so gelatinous and pulpy that it seemed as if it were cast in gelatine, and a portion removed for microscopic examination, when placed between two slips of glass, spread out like a fluid. * * * I had had some experience in tying arteries on the human subject, and I at one time conducted a very extensive series of experiments on the effects of the ligature of arteries on the inferior animals; but I never saw a case in which the ordinary ligature of silk or linen thread yielded or slipped, and never knew a case in which the constricting circle gave way, as in this case. Under these circumstances, whilst I believe carbolized silk or linen thread may be perfectly safe, I cannot avoid the conclusion that catgut, however prepared, is liable to become altered, softened, and disintegrated by the heat and moisture of the living tissues around it, and thus allow the deligated vessel again to become permeable. I learn also that in a case of amputation of the thigh in which the femoral artery had been tied with catgut, hemorrhage occurred from the ligature slipping off." (*Lancet*, September, 1869.)

We have quoted this case at length, because it seems to us conclusive. One such case of positive disaster should outweigh a multitude of successful cases.

We have studied the formation of "living ligatures" in the comb of the cock. Our plan was to make a puncture on one side of the comb, and through this puncture to carry, by a *porte mechê*, a piece of carbolized catgut two inches long folded in the middle. The ends being tucked in, the puncture was sealed up with carbolized collodion. The operation was then repeated on the other side of the comb, using plain catgut and plain collodion.

It will be understood that these two bits of gut were parallel to one another, ranged in the long axis of the comb, and were passed in introducing them from behind forwards, as far as possible, and nearly to the bird's beak, but not far enough to make a second puncture in the anterior part of the comb.

FIRST SERIES, September 6.

Carbolized gut passed along left side of comb	A	Cock No. 1.
Plain gut passed along right side of comb	B	
Carbolized gut passed along middle of comb	C	Cock No. 2.
Plain gut passed along middle of comb	D	Cock No. 3.
Carbolized gut passed along left side of comb	E	Cock No. 4.
Plain gut passed along right side of comb	F	

November 2d, two months after, cocks No. 2 and 3 were killed. The carbolized gut in No. 2 had entirely disappeared, and its position was indicated only by a black line. This black line seemed to be surrounded by a sheath-like cyst, containing a liquid having in it some nucleated cells of diverse sizes. The plain gut of No. 3 was encysted, and though weakened and even rotten, was unaltered in shape and size. December 7th, three months after the commencement of the experiment, killed No. 1 and No. 4. In No. 4 the plain gut F was rotten, but perfect in form, and save for the decomposition just as when introduced. It was encysted, and from the cyst it was easily removed, and again replaced. In No. 1 B was like F in every respect. On the other hand, the carbolized gut of 1 and 4, A and E, had altogether vanished. The places which they had occupied in the comb were indicated by a series of black dots, evidently the remains of a black line, as in C of No. 2. In both these a sheath or cyst was formed surrounding the row of black dots, and in both *this sheath was compacted into a cord in size about equal to the catgut employed in the experiment.* Here and there this sheath inclosed a glairy matter, through the centre of which passed the line of black dots.

SECOND SERIES, December 3.

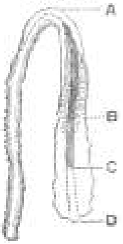
Plain gut passed down middle of comb	A	Cock No. 1.
Carbolized gut passed down middle of comb	B	Cock No. 2.
Carbolized gut passed down left side of comb	C	Cock No. 3.
Plain gut passed down right side of comb	D	
Plain gut passed down left side of comb	E	Cock No. 4.
Carbolized gut passed down right side of comb	F	

December 17, two weeks after operation, killed No. 1 and No. 2. A (plain gut) was encapsuled, softened, and covered with a little purulent lymph. B (carbolized gut) was also encapsuled, and its free ends (nearest the puncture) were softened, and looked like jelly. Along the centre of this jelly-like mass ran a black line. The rest of the gut was very much softened, but not gelatinous. The loop end least so. It was not possible to remove this from the cyst, owing to its softened condition, and also to the fact that an anastomosis of the vessels (?) seemed to pass through its substance from one side of the cyst wall to the opposite, thus uniting gut and cyst firmly together.

January 14th, nearly six weeks after operation, killed No. 4. The plain gut E was encapsuled, softened, weakened, but not rotten nor gelatinous. The carbolized gut was encapsuled and firmly fixed. It may be remarked here, that this capsule inclosed only one strand of gut. The capsule, therefore, seemed double because it was bent on itself, following the bendings of the gut, and being moulded as it were to this. The free ends (nearest the wound) of the gut were perfectly fluid, containing the black tracing in the middle. On laying open the second thirds of the capsule, it was found that both the second or middle thirds of the gut were in a diffluent state, save a central core, which, however, was quite rotten. On laying open the capsule at its last thirds, *i. e.*, at its bend, the gut was found perfect in form, but rotten. It was not easy to lift this bent third of the gut out of its sheath after the latter had been opened. This was due to an interlacing of fibres (possibly vessels) through its substance from one sheath wall to the opposite, as in B. This is shown in Fig. 1.

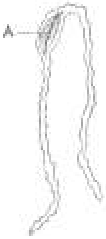
February 10th, nearly ten weeks after the operation, killed No. 3. The plain gut D was rotten and diffluent, and an attempt was evidently being made to remove it. The carbolized gut C had quite disappeared, and its place was occupied by the cyst which had surrounded it, shrunken into a cord: this at first sight seemed to be the gut itself. However, at the bend of this cord there was a very minute cyst filled with glairy matter, the last trace of the carbolized gut. This is shown in Fig. 2.

Fig. 1.



Cyst containing a carbolized ligature, one-half laid open: From C to D the ligature was wanting and its place indicated by a row of black dots. From C to B the ligature was diffluent, presenting a nebulous appearance. From B to A the ligature was tolerably firm, though rotten and attached to the cyst walls by fine interlacing fibres.

Fig. 2.



An old "living ligature" containing a small cyst at A laid open.

From these experiments we conclude :—

1st. Carbolized catgut is more easily decomposed by contact with living structures than non-carbolized catgut.

2d. The "living ligature" is merely the capsule which (at first thrown around the foreign body, possibly for its removal) has contracted into a firm cord.

When carbol is administered to a man in doses of six to eight grains, dissolved in a wineglassful of water, the following phenomena present themselves :—

1st. A loss of sensibility in the mouth and throat, or a feeling of numbness, as when aconite is applied to the lips : this is followed by a cooling sensation, like that produced by mint.

2d. Slight nausea, especially if the stomach is empty. This is succeeded by an uneasy feeling in the abdomen, like that felt before an attack of gravel.

3d. Slight vertigo, ringing in the ears, and partial deafness, judged by the ticking distance of a watch. This vertigo is so great, if the carbol is taken just after rising (and of course on an empty stomach), as to compel the resumption of the horizontal position.

4th. Loss of heart-beat, the pulse, according to our repeated observation, and on different individuals, losing from four to eight beats in a minute, failing also in fulness. The temperature under the tongue undergoes no noteworthy alteration.

5th. Diarrhœa. This is not invariable, and does not appear until several doses have been taken. If present it usually disappears on the third or fourth day of the continued administration of the medicine.

6th. After long-continued use of the medicine, feebleness of heart-beat, muscular debility, and loss of flesh occur.

On omitting the medicine after it has been taken for several days, flatulence usually occurs, accompanied with a feeling of depression, like that felt after the stimulating effects of morphia have ceased.

After taking the medicine in doses of forty-five grains in the twenty-four hours, we entirely failed to detect it in the pulmonary exhalation by Berthelot's test, although many gallons of expired air were examined, and the observation made within a half hour after the ingestion. Lemaire states that the lungs are the chief emunctories of carbol. Thus, after taking it in quantities of a gramme a day dissolved in a thousand parts of water, he declares that he expired it all day long, and that his urine smelt of it, though feebly (p. 95); and, again, on p. 107 he declares that, according to his experiments, the greater part of phenic acid introduced into the stomach is eliminated by the lungs. We will only add, that our experiments were made with care, and with knowledge of this assertion of Lemaire. We can further say that we have never observed the odour of carbol either in the breath or in the urine of those to whom it has been administered: one-half of one per cent. added to urine communicates a distinct odour of carbol to that liquid. We suspect that Lemaire has trusted to his sense of smell rather than to a chemical test in making these assertions, in support of which he offers no proof—at least not in the work from which we have quoted. We have failed to discover it in the feces, and in the sweat after violent exercise. Our observations are, however, limited to cases in which a drachm, or less, in the twenty-four hours was administered.

The urine, according to our observations, after ingestion of thirty to forty grains of carbol in the twenty-four hours, is natural in colour and odour, and deposits, by boiling, no albumen, but a little phosphates only, so that it readily clears up on addition of an acid. But if the heat is applied for some time—and the liquid need not boil—so that it is one-third evaporated, a brownish discoloration will be observed, which speedily changes into a black precipitate, coloured grayish, however, by admixture with the large amount of phosphates precipitated at the same time. After this precipitate subsides, the urine is found clear, and the further action of heat fails to produce any unusual changes. In one case, after taking forty-five grains of carbol, the urine of the twenty-four hours yielded a grayish precipitate, which, after washing with dilute acetic acid, and drying at 100° C., weighed two hundred and eight grains. Before the blowpipe, this precipitate took fire, and burnt with a sooty flame and a singed-hair odour, leaving a black coal, which yielded chlorhydric acid, a large amount of iron, and phosphates. The former was thrown down by ammonia water in rusty flakes; the latter appeared as a microscopic deposit of triple phosphate. The gray precipitate was partially soluble in dilute hot potash solution, with an odour like that produced by the action of dilute potash solution on albuminoids in general. From this solution an acid threw down a glairy precipitate like globulin. Chlorhydric acid also dissolved the gray precipitate in part, and yielded, on addition of an alkali, iron, phosphate, and a body containing carbon and nitrogen. Ordinary sodic phosphate was without action on the gray precipitate. Water, alcohol, and ether failed to dissolve it. We know of no substance in the body, save hæmatin, which contains at once the amount of iron and phosphates called for by this body. We made no quantitative estimation of these, but this was not needed to satisfy us that both iron and phosphates were present in large quantity. Of course the quantity of the precipitate obtained precludes the supposition that the body in question was a derivate of carbol. It was evidently an albuminoid, and from all the facts in the case, we believe it was hæmatin altered by or combined with carbol. We do not pretend to account for the impunity with which the body was deprived of two hundred grains of hæmatin *per diem.* We cannot find that any one has noticed this substance. Its appearance must not be confounded with another phenomenon long observed after ingestion, by mouth or skin, of creosote, tar, and carbol. We refer to the smoky or brown coloration observed in the urine under these circumstances, especially when from any cause the urine is ammoniacal. If such urine is placed in a tall jar, the browning will be observed to commence at the surface and proceed downwards. It seems to form *pari passu,* with the decomposition of the urea, into ammonia, and it usually renders the whole urine black-brown in three weeks. This solution has been the subject of discussion and experiment by several observers, thus: "Dr. Wallace concluded that the carbolic acid was carrying off the pigment of the red corpuscles. * * * Dr. Stevenson, of Guy's Hospital, London, showed that urine darkened by the systemic absorption of carbolic acid, did not contain more than the normal quantity of iron. He considers that the colouring matter was not derived from the blood. The most probable hypothesis is, that it comes from the *changed carbolic acid* itself. (Sansom, p. 283.) We coincide with this last opinion, and we even hazard a conjecture as to the nature of the change, and the name of the derivative. It must be obvious from analogy, in the first place, that any change which carbol undergoes in the body must be one of oxidation. As a rule, this is true of all substances, especially those whose educts appear in the urine. We must expect to find carbol transformed, by the time it reaches the kidneys, into a body containing more oxygen. Chinon, whose formula is $C_6H_4O_2$, is such a body. We have a perfect analogy to the changes we have indicated as happening to carbol, in the changes which alcohol (in part, at least) is supposed to undergo in its passage through the body. We may compare the changes of the two bodies, thus:—

$$\underset{\text{Alcohol.}}{C_2H_6O} - 2H = \underset{\text{Aldehyde.}}{C_2H_4O} + O = \underset{\text{Acetic acid.}}{C_2H_4O_2}$$

$$\underset{\text{Carbol.}}{C_6H_6O} - 2H = \underset{\text{Unknown}}{?} + O = \underset{\text{Chinon.}}{C_6H_4O_2}$$

That is, alcohol and carbol lose two atoms of hydrogen, and gain one atom of biatomic oxygen.[1]

So far then the case stands thus: There is a probability that carbol in its passage through the body is converted into chinon. We must now offer some corroborating evidence of this proposition, and we will be as brief as possible. Chinon presents the singular property of becoming reddish-brown when allowed to stand for a while in aqueous solution. This change is promoted by heat and by addition of ammonia; the brown becomes almost a black. These phenomena, as we have seen, occur in urine after carbol ingestion, and in fact they constitute the matter under discussion. In the next place we will find that certain reactions can be observed in urine after carbol ingestion—which must be due to the presence either of chinon or carbol—we throw salicine, aniline, and the rest out of the question; they are not present. Thus, after taking forty-five grains of carbol, the urine, if acted on by chlorine, or better by enchlorine of Davy (obtained by action of chlorhydric acid on potassic chlorate), yields the peculiar odour which dilute carbol or chinon solutions do under similar circumstances, and as the action of the chlorine proceeds a minute quantity of what we take for perchlor-chinon is formed, colouring the foam of the urine pale yellow. The case then seems to narrow down to the presence either of carbol or chinon. Let us show now that carbol is not present, and we will have another fact pointing to the presence of chinon. It is true that carbol cannot be detected by the direct application of Berthelot's test to urine. We have noticed that, even after the occurrence of the blue coloration indicative of carbol in a liquid, the addition of urine immediately rendered it colourless;[2] but, if we add even the one-hundredth of one per cent. of carbol to urine and distil it, we can readily detect carbol in the distillate by Berthelot's test. This plan applied to urine passed after ingestion of carbol has invariably in our hands failed to indicate carbol. We consider this fact conclusive, therefore, that carbol does not appear in the urine after its moderate or non-poisonous ingestion. The foreign body contained in such urine which is acted on by chlorine yielding perchlor-chinon, is again proved to be chinon. One more proof and we have done. We affected 600 cc. of urine with a little chlorhydric acid, just as in the usual way for estimating the quantity of uric acid in urine. Of this 200 cc. was placed in a beaker by itself, 200 cc. in another beaker containing a trace of chinon (the urine, by the way, becoming blood-red, a phenomenon observed, by several writers, in urine after carbol ingestion), 200 cc. more were placed in a third beaker containing a small quantity of one per cent. carbol solution. The beakers were then covered with paper and put away for the formation of uric acid. After twenty-four hours crystals of uric acid were first observed at the bottom of the beaker containing carbol, and twelve hours later crystals were observed in the beaker containing urine only. But at no time, not even after the other two liquids were crowded with crystals of uric acid, were any crystals observed in that beaker to which chinon was added, but in place thereof a pale muddy precipitate in small quantity was observed at the bottom of the beaker. The appearances obtained in this last case are found when, after the ingestion of carbol, we seek to discover and estimate the uric acid by addition of a little chlorhydric acid, *i. e.*, we have no uric acid in crystals (or but a trace) but a quantity of a muddy precipitate. These arguments we think are sufficient to secure at least respect for our conjecture, that chinon is found in urine after ingestion of carbol as a product of the oxidation of the latter. We forgot to mention that chinon is not poisonous to dogs in quantities of a drachm. (Wöhler and Frerich's *Annalen Phar.* 65, p. 343, quoted in Gmelin's *Handbuch der Chemie.*)

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[1] This reaction, by which carbol is converted into chinon, we have succeeded in effecting in the laboratory by the action of potassic bi-chromate on carbol. The chinon volatilizes, and should be condensed in a tube.

[2] This phenomenon is due to uric acid. If an aqueous solution, coloured blue by addition of Labarraque's liquid and ammonia (the latter must not be in excess), be shaken with uric acid, the colour is discharged. The colour can be restored by ammonia.

In the table below the effect of carbol ingestion on the urine is set forth; the most noticeable thing is the lack of uniformity in its action. As we remarked, when speaking of the uses of carbol, that every case is an experiment, so in the effects on the urine every case is a law unto itself.

The urinary water, the specific gravity, and the colour were unaffected.

The urea slightly increased.

The phosphates greatly increased.

The uric acid frequently could not be observed at all,[1] and always there was such a quantity of muddy deposit that its exact estimation was impossible.

The acidity was increased.

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[1] Fuller has noticed this circumstance, and thinks carbol prevents *formation* of uric acid. In cases where considerable uric acid deposits had been occurring, these disappeared quickly under action of carbol. He applied his ideas unsuccessfully to the treatment of gout.

Table of Analyses showing the influence of Carbol on the Urine.

		NO CARBOL TAKEN.					CARBOL TAKEN.					
		Total urine of 24 hours.	Urea of 24 hours.	Phosphoric acid of 24 hours.	Uric acid of 24 hours.	Total acidity in acetic acid.	Total urine.	Urea of 24 hours.	Phosphoric acid of 24 hours	Uric acid of 24 hours.	Acid of urine estimated as acetic acid.	
Healthy man, æt. 34.		cc.	grms.	grms.	grms.	grms.	cc.	grms.	grms.	grms.	grms.	
	1	1370	27.04	2.70	.524	2.9	1450	31.17	2.90	.36		5
	2	1980	31.68	..	.680		1600	31.20	2.86	none		6
	3	1750	31.50	..	.530	2.4	1500	30.75	3.80	none	4 5	7
	4	1200	..	2.52			1250	31.25	3.40	.30	5	8
							1480	38 48	3.19	.41	3.4	9
Average		1575	30.07	2.61	.578	2.6	1556	32.57	3.23	.21	4.3	
Cancer patient, No. 1, æt. 70.	1	920	22.08	1.17		Alkaline	570	16.24	1.91		Faintly acid	4
	2	445	14.46	.95			875	18.67	1.78			5
	3	720	16.05	1.02			930	16.20	1.50			6
Average		695	17.53	1.04			758	17.03	1.73			
Bubo patient.	1	900	23.22	1.47	.429		880	23.76	1.58	.450	4.3	3
	2	1185	23.80	1.89	.300		850	22.20	1.51	.480	5.2	4
							910	24.50	1.54	.500	4.5	5
Average		1042	23.51	1.68	.354		880	23.48	1.52	.476	4.6	
Polyuria patient.	1	9850	26.80	1.90			10700	27.03	3.75			4
	2	8500	29.50	2.00			8640	28.12	3.20			5
	3	11670	27.04	1.97			9945	30.12	3.80			6
Average		9990	27.78	1.95			9762	28.42	3 58			
Cancer patient, No. 2, æt. 30.	1	1050	20 01	1.80	.570	2	1160	21.75	1.95	.047	3.4	4
	2	1120	19 70	1.49	.585	2.3	940	21.08	2.30	.021	2 9	5
	3	1010	20.50	1.60	.600	1.9	1090	20 20	2.97	none	4.0	6
							1025	22.00	2.14	.050	3.6	7
Average		1060	20.07	1.63	.585	2	1053	21.25	2.24	.029	3.5	
Healthy man.	1	1500	31.42	2.70	.530		1450	33.27	3.19	?		3
	2	1430	31.99	3.11	.601		1930	33.93	2.89	?		4
Average		1465	31.70	2.90	.565		1690	33.60	3.04			

We can say but little for the success of carbol as an internal remedy, and, although we have tried it in a variety of affections, we have seen good results in only one or two. The medical journals, however, teem with cases of its successful internal administration. Scarlet fever, measles, smallpox, typhoid, and malarial fevers, and even phthisis and syphilis, have received—as it is alleged—checks from its use in this way.

In the first place, we may call attention to the cases in which Lemaire has used it. The detail of these cases occupies more than one-third of his work, but with the exception of those cases in which the carbol was used as a local agent to subdue inflammation, or to destroy a parasite of the skin, his results seem fanciful, or unimportant. Sansom has given a table of cases in which "sulpho-carbolate of soda" was used in typhoid fever.

His results, taken at the very best, are not favourable, for out of twenty-four cases he had three deaths, or a little over twelve per cent., a low, but by no means unusually low, mortality. But, on examining the table closely, it will be found that no less than nine of these cases were under the age of ten years. These should have been excluded (for typhoid, practically, has no mortality under this age), so that we get three deaths in fifteen cases—one in five,—or twenty per cent., a mortality above the average. The table then proves nothing. Pecholier, of Montpelier, reports on sixty cases of typhoid treated by (carbol?) creasote. He asserts that it hastens recovery, provided it is given in doses of three drops from the very commencement of the disease, whilst in those cases in which the treatment was commenced after the disease had made progress, it was of no avail. M. Pecholier started out with the theory that in typhoid there is present,[1] as a cause, an organized ferment to be killed. He believed that carbol would kill the ferment, and so cure the disease. Is the judgment of a man thus prejudiced to expect a particular result trustworthy, for the consideration and discrimination of results of treatment in typhoid fever, in which the mortality is so variable and dependent on so many different circumstances?

Freulich reports eight cases of inveterate intermittent with enlarged spleen, treated successfully by a total medication of four and an eighth grains of carbol! (*New York Medical Journal*, from *Wien Med. Pres.* xii., 1867.) Drs. Barrant and Tessier, at the Mauritius, have used carbol in grain doses thrice daily in intermittents. The results compare favourably with quinia. They also employed hypoderms one grain to thirty minims. (*Lancet*, May, 1869, p. 279.)

Dr. Fuller, of St. George's Hospital, London, prefers carbol to creasote in the treatment of diarrhœa.

It has been extensively used in a pulverized form as an inhalation in phthisis, and has even acquired a popular reputation in this way. We have failed to derive the slightest benefit from it in several cases, all in the suppurative stage, beyond what the same amount of steam might have produced.

In chronic rheumatism, given in sheer desperation after the failure of every remedy, we can report five unsuccessful cases.

It is worse than useless in gonorrhœa, and seems to aggravate nasal catarrh, according to our experience.

It has been used as an injection in ascarides, but its employment is fraught with danger, as Lemaire has shown.

It is used extensively in Hebra's wards, and has been especially serviceable in psoriasis, pityriasis, and pityriasis rubra, as a *curative* agent. It is given in pills. The dose is six to ten grains gradually increased to twenty or even to sixty grains in the day. The smoky urine after this use of carbol has not been noticed. (Quoted in *Am. Journ. Med. Sci.* for April, 1870, from *Arch. für Dermatologie und Syphilis.*) Employed externally we have never failed to afford relief to the itching of urticaria, eczema, and psoriasis, and we believe that it would not fail in true prurigo. Usually, we order a simple wash of 2 per cent. carbol solution. If, however, there are open sores, such as we find in the eczema succeeding an ulceration of the veins of the leg, then oily applications are better, and we use carbolized oil 1 : 10 on rags, with oiled silk over all. We would say more on this subject if it would render our statements of any more force. We use carbol in every skin disease where itching is complained of, and we have not seen it fail to relieve this symptom. We may state here that we have not seen any constitutional effects from carbol used for this purpose, and in the manner indicated. Its use as a parasiticide requires much caution, owing to the amount and thoroughness of the application required. It has been proved by numerous observations that carbol is really absorbed through the skin, and if thrown, *as carbol*, directly on the great nerve-centre, the effects may readily be disastrous. There is no doubt, from cases recorded by Lemaire, Sansom, and others, that grave constitutional mischief is sometimes occasioned even by its application to a limited surface, or to a small wound.

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[1] Quoted from Gazette Hebdomadaire, xiii., 1869, in Half-Yearly Abstract Med. Sci. for July, 1869.

Carbol has been used in cancer, and reported well on. Dr. F. A. Burrall, of New York, has reported[1] a case of mammary schirrhus, remarkable for its successful treatment by the internal use of carbol. The diagnosis was made with care, and was assured by the concurrence of several surgeons. The tumour was ulcerated, the seat of frequent hemorrhages, and was discharging fetid pus. The patient's general state was cachectic. Carbol lotions had previously been used, but without benefit. The patient was placed upon quinia, and carbol in four-drop doses thrice daily. No change took place for two months save that the pain was mitigated. At the end of this time the tumour began to soften, the ulcers to heal, and at the expiration of six weeks she was again at her work as a washerwoman—the tumour not gone entirely but practically removed. Lemaire records a case of epithelioma healing quickly under the external use of carbol, p. 491, and a second in the practice of M. Gonel, also healing by its external use, p. 493. At p. 494 he records an unsuccessful use of the remedy in the same disease, although the pain was ameliorated, and in the same place he quotes Dr. Declat to the effect that the remedy internally and locally had benefited, if it had not cured, a case of cancer of the tongue. He records four or five other cases of cancer (scirrhus) in which carbol, externally applied, gave great relief: he does not seem to have used it internally.

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[1] Medical Record for November, 1869.

We have treated four cases of cancer with the remedy.

The first in an old man from whom we had removed an epithelioma of the lower lip. The disease returned in the cicatrix. Circumstances forbade a second operation. We placed him on sixteen grains of carbol (in divided doses) a day, and kept up the treatment for forty-nine days. At the end of this period it was found that the disease had quite disappeared. In this case the treatment by carbol was continued, for precaution sake, until the man began to lose flesh and muscular strength. Tonics were then substituted. This occurred in 1869, and the man has not been since troubled with his complaint.

The second of our cases was also epithelioma. We had twice excised parts of the lower lip, the last time using carbol locally as an anæsthetic. After the second operation the parts healed almost by the first intention, so rapidly indeed that the sutures were with difficulty removed. The parts remained sound for a while, but at length became the seat of one or two hard, wart-like ulcers, the source of sharp pain. Carbol was given internally in doses of fifteen grains a day. The ulcers healed, the nodules vanished, and with them the pain. The man has had no return of his disease.

The third case was one of encephaloid of the neck, which ultimately increased to an enormous size, involving every tissue between the skull and the thorax. The man of course suffered greatly. In the earlier stages of the disease, carbol in five-grain doses, thrice daily, arrested its progress, and greatly assuaged the pain. But the loss of flesh and strength was so great under its use that it was necessary frequently to suspend its administration, and in these intervals the disease made up for lost time. Finally carbol seemed to have no effect whatever, and only the most prodigious doses of opium and chloral gave ease. The man died from the immediate effects of these two remedies (comatose) which he was allowed to use *ad libitum*. Our lack of success in our later administration of carbol in this case may have arisen from the fact that we employed glycerine as the menstruum, hoping it would be better tolerated by the stomach. Lemaire has shown that glycerine diminishes the effects of carbol.

The fourth case, rodent ulcer of the lower lip and chin, is yet under treatment, but with very promising results. The ulcer, from the size and shape of a tablespoon bowl, has contracted to the diameter of a half-dollar, and granulations still rapidly coming forward. The pain left at once, and the swelling of the glands under the jaw in a few days after the commencement of the treatment. The discharge, which smelt horribly, has disappeared altogether. This man used carbol locally, 5 per cent. solution, and internally five grains four times a day. It has not affected his health in any way as yet, although he has taken it for nearly a month.

For dispensing, carbol can be most conveniently kept in the liquid state. A very small quantity of water added to melted carbol will prevent its return to the crystalline form at ordinary temperature. A minim of carbol thus liquefied corresponds almost exactly to a grain—one fluidrachm weighs sixty-one and three-quarter grains. In our opinion this should be the officinal "carbolic acid" of the U. S. Pharmacopœia. Carbol should not be given in a stronger solution than three grains to the fluidounce of water. As before noticed, in Vienna it is given in pills. It is hardly necessary to observe that these should be freshly prepared. Possibly the albuminous jelly described on p. 26 might be found useful. It is in preparing carbol for external use that the pharmaceutist will find most need of skill. We prefer as a solvent for carbol in surgery perfectly sweet salad or lard oil. We keep an oil composed of equal parts of carbol and sweet oil as stock. This is labelled "normal carbol oil," and for external use is quite as strong as can ever be justifiable. In prescribing compounds of lesser strength we write simply Carbol ol. 1 : 10, *i. e.* two parts of normal carbol ol. and eight of sweet oil, containing, therefore, in ten parts nine parts of oil and one of carbol, by measure. If cerate is wanted all that is necessary is to substitute melted wax, free from paraffine (in which carbol is insoluble) for oil, and stir the mixture until it is stiff. Normal carbol oil is coloured red with alkanet to prevent mistakes.

Carbolized collodion should be prepared in small quantity at a time. That long kept is irritating, possibly from presence of picric acid.

Carbol can scarcely be called a poison, although several deaths from its reckless use are on record. It seems to be more obnoxious to some individuals than to others, and, as a rule, badly borne by children, just as with alcohol. Indeed, it has been noticed by some one (the authority escaping our memory) that those who have been accustomed to alcohol—as spirits —and therefore insusceptible to it, are likewise insusceptible to carbol. Two persons died from the use of carbol as a general wash to the surface of the body, in the Aston work-house at Birmingham. The crude liquefied acid was the preparation used. A third person, similarly treated, recovered, which ought to be proof that carbol is *not* a poison. (Machin, *British Medical Journal*, 1868.) Lemaire records its constitutional effects from its local application in six cases of lepra. He nearly lost a child by a very dilute injection to dislodge ascarides. We have used carbol a great deal externally, as an anæsthetic, in skin diseases, neuralgia, and the like, as well as for the preventing of inflammation in wounds, not in adults alone, but in children also, and we have not seen a solitary case where it manifested a poisonous tendency. We doubt not that the cases of the judicious use of carbol locally attended with unpleasant general symptoms were instances of idiosyncrasy. It may be admitted that the external use of carbol presents greater elements of danger than the internal ; for, if the solution be strong, and extensively applied, we may have a kind of shock arising from the excessive impression made on the periphery of the nervous system, as in extensive burns. But, besides this, it is worthy of consideration, if liver and lungs may not act as destroyers of carbol when taken internally, so that even excessive doses are scarcely felt at all if dilute, whilst, when applied externally, it may be carried direct to the nerve centres as carbol, and kill by direct action on these. Internally, carbol can hardly be called a poison. It is probable that a five per cent. solution would kill, but the action would be a purely mechanical one, like that of caustic potash. The five per cent. carbol solution, if diluted, would be as innocuous as dilute potash solution.

As antidotes to the caustic effects of carbol taken into the stomach, oil and glycerine have been recommended on the theoretical grounds that both these substances impair the action of carbol. It is further an advantage that one or the other of these substances is almost always at hand. We should have more confidence in rotten albumen—as, addled egg—but this might not be easily obtained. To combat the effects of carbol after its absorption, our main reliance should be on the judicious use of alcohol as a nerve stimulant.

The question of the toxic power of carbol would naturally lead us to consider the action of carbol on fungi, etc., and its power to arrest fermentation. The subject, however, is too extensive for our remaining space to admit of discussion, and, besides, such a discussion would involve questions connected with the germ theory of disease, quite as much as with carbol. This is ground we have endeavoured, when possible, to shun in the paper now concluded.

From the facts laid before the reader, we think that the conclusions are justified—

1. It is not proven that carbol is a general disinfectant.

2. It is of the greatest use to disinfect wounds.

3. It accomplishes this (*a*) by destroying pus, etc.; (*b*) by preventing inflammation.

4. Its use in wounds moderates pain.

5. Its use on the skin relieves itching, and produces an anæsthesia sufficient for minor cutting operations.

6. It seems to be of use internally, in certain cases, in scaly skin diseases, and at least as a moderator of pain in cancer.

7. It has not proved of decided use in other diseases.

Fort Vancouver, W. T., December 1, 1871.